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BIOLOGICAL BULLETIN

STUDIES ON THE RELATION BETWEEN AMITOSIS AND MITOSIS.

IV. Nuclear Division in the Somatic Structures of the Proglottids of Moniezia.

V. General Discussion and Conclusions Concerning Amitosis and Mitosis in Moniezia.

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IV. Nuclear Division in the Somatic Structures of the Proglottid of Moniezia.

1. *The Genital Ducts.*

The various genital ducts of the cestode proglottid appear to arise by the division and differentiation of the parenchymal cells, if the syncytium which composes the parenchyma can properly be said to be composed of cells.

Moreover, this division and differentiation apparently occurs *in situ*, at least to a large extent, and not by outgrowth of the cells from a particular region. As was noted in the first paper of this series the development of the reproductive organs begins, or at least first becomes visible, in a region near the longitudinal nephridial canals and the lateral nerve cords, *i. e.*, midway between the region where the ovaries will appear and the lateral border of the proglottid (Child, '07*a*, Figs. 1*a*, 1*b*), the first portion to appear being parts of the ducts. The earliest indication of development is an increase in the number of the parenchymal nuclei in this region (Child, '07*a*, Figs. 2 and 3). The area of proliferation gradually extends in both directions and the "cells"

differentiate into the ducts and terminal organs. The development of the ducts does not appear to be an outgrowth from the region first involved, but seems rather to be due to an extension of certain stimuli or conditions in the parenchyma which bring about proliferation and gradual differentiation of all cells which lie within the region affected. I have found it impossible to reach any other conclusion regarding the development of these ducts. Moreover, in the earliest stage of the ducts I have never observed a single case of mitosis or anything resembling it. On the other hand Figs. 2 and 3 of my earlier paper (Child, '07*a*) show that amitoses are frequent. In the early stages there is a marked difference in size of the nuclei in the central and peripheral portions of the area in which proliferation is occurring. This is very clearly shown in Fig. 2 (Child, '07*a*). Here the nuclei about the periphery of the proliferating region are of the same size as the nuclei elsewhere in the parenchyma, but toward the center their size decreases until they are only a small fraction of the size of the parenchymal nuclei in general. Evidently proliferation is much more rapid in the central than in the peripheral regions of the proliferating area.

In somewhat later stages the rapidity of division apparently decreases and the nuclei of the central regions gradually increase in size until they are almost or quite as large as those about the periphery. At this time the ducts are visible as bands or cords of very numerous nuclei each surrounded by small areas of cytoplasm. Between the ducts and other portions of the parenchyma, however, no limiting membrane exists nor do the "cells" appear appreciably different in character from those composing the parenchyma.

From this stage on the differentiation of the walls of the ducts gradually takes place; muscle-fibers develop, a lumen appears, and nuclear division becomes less and less frequent.

In Figs. 1–5 (Plates VIII. and IX.) typical portions of the duct-regions before differentiation has begun are shown. Fig. 1 (Pl. VIII.) is taken from the lateral end of the developing ducts at a time when the proliferation has extended to a point midway between the longitudinal nephridial canals and the lateral margin of the proglottid. From right to left the figure includes the whole width

of the proliferating area from which this portion of the ducts will develop. The axis of the developing duct corresponds to a line drawn vertically through the middle of the figure. The nuclei are just beginning to be affected by the conditions which produce proliferation ; thus the figure represents approximately the earliest stage at which this portion of the ducts is distinctly visible. From the cord of cells in this lateral region both vagina and vas deferens differentiate, but there is no distinction between them until much later stages.

Fig. 2 (Pl. VIII.) represents a section similar to Fig. 1 of the cord of cells from the same region at a somewhat later stage. The nuclei are more numerous and amitoses are apparently more frequent. At the right is one of the very rare cases of mitosis observed in the development of the genital ducts. It will be observed that it lies on the border of the region involved in proliferation and the same is true of most other cases observed. Not a single case of mitosis has been observed in the axial region of the cell-cords from which the ducts arise and only six cases of mitosis have ever been seen outside the ovaries and testes in *Moniezia expansa* and *M. planissima*, though extended search for them has been made.

Fig. 3 (Pl. VIII.) is a section similar to Fig. 1 of the cord of cells from which the vas deferens develops, taken from a point near its upper or inner end where it does not adjoin the vagina. As regards nuclear division this figure is very similar to the preceding. On the right is shown one of the cases mentioned and figured in earlier papers (Child, '07*a*, '07*b*, '07*d*) where the two parts of a nucleus which is apparently undergoing amitosis stain differently.

In Fig. 4 (Pl. IX.) a transverse section of the vas deferens at a somewhat later stage after the lumen has appeared is shown. Amitotic nuclear divisions are still taking place, but apparently less rapidly than in earlier stages, or else the nuclei increase in size more rapidly between successive divisions.

Fig. 5 shows a portion of a vas efferens near its junction with others. Two cases of undoubted amitosis are visible. Fig. 6 is from the outer portion of the wall of the oviduct and includes one case of mitosis besides several amitoses.

The preceding figures are sufficient to indicate the general type of development of the genital ducts as regards division. Since we are concerned with the cytology rather than with the morphology, it is unnecessary to follow the development of the structures step by step, for the later stages show nothing of importance cytologically, which cannot be observed in the earlier stages. Amitosis continues to be the characteristic method of nuclear division throughout the development.

2. *Other Proglottidal Structures.*

The remaining figures (Figs. 7–19) are selected as examples from a large number of camera drawings of parenchymal structures.

Fig. 7 (Pl. IX.) probably represents one of the smaller nephridial ducts at an early stage in transverse section. One very clear case of amitosis and two other probable cases are visible.

Fig. 8 (Pl. IX.) and Fig. 9 (Pl. X.) are taken from the region of the lateral longitudinal nerve-cords in the growing region just posterior to the scolex. In this part of the body the cytoplasmic areas about the nuclei are more extensive than further posteriorly.

Figs. 10–14 (Pl. X.) show cells and syncytial masses from the general parenchyma in the region where the proglottidal boundaries are just becoming visible, *i. e.*, in a region of rapid proliferation of the parenchymal nuclei. Not a single case of mitosis has ever been observed in this region.

Two cells from the interproglottidal glands are shown in Figs. 15 and 16 (Pl. X.) at a stage where differentiation is advanced. In early stages the regions where these glands appear are not visibly different from other regions. The first visible indication of gland-development is the formation by amitotic proliferation of groups of nuclei along the interproglottidal boundary. Each of these groups gives rise to a considerable number of elongated unicellular glands like those in the figures, arranged radially about a common outlet. Amitosis is much more frequent before differentiation occurs, but as Figs. 15 and 16 indicate, often occurs after differentiation is somewhat advanced. The figures show the earliest visible stages in the formation of the secretory product. The cytoplasm gradually becomes filled with deeply staining, granular masses.

Cuticle-forming cells of the external layer of the body are shown in Figs. 17–19. These cases are taken from the region where proglottids are beginning to form: in this region division is more frequent in these cells than in proglottids advanced in development.

It is perhaps unnecessary to repeat that these figures are merely a few cases selected almost at random from among my camera-drawings. The number of figures might be increased almost indefinitely if desirable, but I think these are sufficient to show that amitosis is a typical feature of development in *Moniezia* both in the germ cells and in the soma.

Unfortunately it is at present impossible to complete my observations by examination of the stages between the embryo and the adult tape-worm, for the life-history and intermediate host of the genus are unknown.

V. General Discussion and Conclusions Concerning Amitosis and Mitosis in Moniezia.

Before any general interpretation of the facts concerning the rôle and frequency of the two forms of division is possible it is necessary to know something regarding the physiological conditions which determine the occurrence of each of the two methods of division. At present, however, we have no real knowledge regarding these conditions and are limited to hypotheses and surmises. In a recent paper (Child, '07*c*) I have made certain suggestions along this line to which attention may be called here.

It was pointed out in the paper referred to that the stimulus to nuclear division and growth is apparently not identical with the presence of an excess of nutritive material, for it is a well known fact that extensive regeneration will occur in many forms, *e. g.*, *Planaria*, even after reduction of the body by long continued starvation, to a fraction of the original size. In such cases the regenerating region derives its nutritive material from other regions of the body, which consequently decrease in size more rapidly than in individuals where no regeneration is taking place. Evidently in such cases the nutritive material goes to the regenerating region at the expense of other parts because the demand is greater there than elsewhere. In short, conditions exist in this

region in consequence of which it deprives other regions of material. Doubtless these conditions are largely chemical in nature.

The existence of such conditions in this and other similar cases justifies the conclusion that the stimulus to cell-division and growth is not identical with the presence of excess of nutritive material. Admitting the existence of a stimulus to division independent of the presence or absence of nutritive material we may expect to find conditions different within the cell or nucleus, according as the changes which occur in consequence of the stimulus are or are not balanced by the intake of material. In case they are balanced, a condition of equilibrium is more or less perfectly maintained or else changes in both directions from the condition of equilibrium alternate more or less rhythmically. In consequence of the complex character of the cell and the more or less central position of the nucleus, the occurrence of rhythmical cyclical changes is to be expected rather than the maintenance of a condition of absolute equilibrium.

If on the other hand the demands of the nucleus are not met by the intake of material the condition of equilibrium is not attained, and the processes in the cell, so far as this point is concerned, are not cyclical, but acyclical or orthodromic.

Now the nuclear phenomena which occur in connection with mitosis are very clearly cyclical; the condensation of the chromatin and the disappearance of the nuclear membrane are followed by an apparent reversal which terminates in the reconstitution of a nucleus and the resolution and distribution of the chromatin.

In amitosis, on the other hand, no such cyclical changes occur. The nuclear structure remains the same throughout the whole process. There is no disappearance or transformation, followed by return to the original condition, of any part. Apparently the process consists essentially in increase in size in consequence of formation of new nuclear material, followed by separation into physiologically independent parts. Nothing in the visible phenomena indicates the occurrence of reversal in direction of the processes involved. Division itself may be due either to physical factors or to the establishment with increasing size of more or less independent regions or centers of activity. The appearance

of new nucleoli in widely separated regions of the nucleus and the difference in tingibility of the two parts of a dividing nucleus, which are often observed in *Moniezia*, indicate the existence of a certain degree of physiological independence before separation of the parts.

If this interpretation of the visible phenomena is correct it appears probable that mitosis is associated with certain cyclical processes, in the nucleus and amitosis with acyclical or orthodromic processes. In other words, in order to divide mitotically the nucleus must be in a condition approximating equilibrium between intake of material and functional transformation. If the stimulus to growth is so strong that the nucleus is forced far from a condition of equilibrium amitotic division may occur. Of course in all cases where the demand exceeds the supply the actual rate of growth or division is determined not by the intensity of the stimulus but by material available. According to my suggestions, it is not rapidity of growth or division which determines or influences the form of division, but rather the relation between the stimulus to growth and the intake of material. Division itself is probably an incidental result of growth. These suggestions are of course merely provisional, being scarcely more than surmises, but they may perhaps serve as a working hypothesis for future investigation of the problem.

But whatever value the future may assign to these suggestions, the facts now known regarding the occurrence of amitosis seem to be in accord with this hypothesis, as will be clear from a brief consideration.[1] Most of the earlier observers agree in the conclusion that amitosis is characteristic of regions of extreme physiological activity connected with assimilation, secretion, etc. (Ziegler, '91 ; Ziegler and Vom Rath, '91 ; Vom Rath, '95, etc.). More recent observations of others and myself some of which are briefly mentioned in my earlier paper (Child, '07*c*) show that amitosis is of frequent occurrence in regulatory growth, which is much more rapid than normal growth. It is also the typical form of division in the imaginal organogeny of certain diptera and very probably of many insects. Here, likewise, the growth is

[1] More extended discussion of the bibliography is postponed until additional data have been recorded.

exceedingly rapid. In certain vertebrate embryos amitosis is apparently much more frequent in the more rapidly growing than in the less rapidly growing regions. In certain forms, such as trematodes and polychætes, which rapidly produce a very large number of generative cells, amitosis appears to be the characteristic method of division in the primitive germ-cells.

All of these cases concern regions of extreme assimilative activity and there are certain indications that, so far as the individual nuclei are concerned, they are regions which are far from equilibrium. In all such regions, for example, the cytoplasm is relatively small in amount, *i. e.*, the nuclei are relatively much more numerous than in less rapidly growing regions; secondly the nuclei in these regions are usually much smaller than in less rapidly growing regions. Often there are differences in this respect between the peripheral and central portions of such regions, the central portions showing more extreme conditions than the peripheral. Evidently the nuclei in these regions do not attain a condition of equilibrium but are forced on in a given direction by some stimulus as rapidly as the material available will permit. According to the hypothesis set forth above these are exactly the conditions in which amitosis may be expected to occur.

But according to this hypothesis also amitosis is not necessarily confined to regions of rapid growth. If little material is available actual growth may be exceedingly slow. Moreover, it is possible that nutritive material may be present outside the cell or even in the cytoplasm, in excess but in consequence of scarcity of cytoplasm or other special conditions may become available for the nucleus only very slowly or not at all. In such cases amitosis might occur in the presence of an apparent excess of nutritive material. Possibly various cases of amitosis observed in nuclei lying in the yolk of meroblastic eggs and surrounded by only a small amount of cytoplasm may be cases of this kind.

And again it is possible that the differentiation of the cytoplasm in certain directions may bring about conditions favoring amitosis; in such cases the amount of undifferentiated cytoplasm may be insufficient to maintain the nucleus in equilibrium. Thus amitosis may be expected, and has often been found in highly differentiated cells.

Doubtless various other conditions may arise in the cell which favor amitosis, but the above consideration is sufficient to indicate the relation between the facts and the hypothesis.

The opinion of Ziegler and Vom Rath (Ziegler, '91; Ziegler, and Vom Rath, '91; Vom Rath, '95) and many later observers, that amitosis is never followed by mitosis, but always leads to degeneration and death is without doubt incorrect. But that degeneration and death should follow amitosis in certain cases is to be expected, if my hypothesis is correct. Under extreme conditions the nucleus or cell many be forced so far from equilibrium that changes occur which render return impossible, and degeneration and death follow. In regions of rapid embryonic growth degenerating nuclei are not infrequently found, but in these, as in other cases, the degeneration is not a necessary consequence of the amitosis, but both are merely indications of a physiological condition, which in many cases brings about amitosis without degeneration, but in extreme cases produces degeneration. Nuclear fragmentation is a frequent accompaniment of degeneration, but even in these cases the physiological conditions may be in general similar to those occurring in normal amitosis.

Returning now to the case of *Moniezia*, the facts concerning the distribution of relative frequency of amitosis and mitosis are briefly as follows. As regards the germ cells, amitosis is much more frequent than mitosis during the development of ovaries and testes (Child, '07*a*, '07*b*). Mitoses are of very rare occurrence during the earlier stages of development, but in some chains and proglottids and gonads appear somewhat more frequently in later stages before the growth-period. This developmental period characterized by amitosis is followed by the growth-period, at the beginning of which a spireme appears, and later by maturation. In the female cells maturation exhibits the features typical of the process in other species (Child, '07*a*): in the male cells typical maturation occurs, but in addition to this a peculiar process of fragmentation of the nuclei of the first spermatocytes is of common occurrence (Child, '07*b*), and apparently results in the formation of nuclei indistinguishable from the spermatid-nuclei formed in the typical manner. Whether these nuclei actually give rise to spermatozoa or not cannot be determined with cer-

tainty, but the observations seem to indicate that they may. The relative frequency of the two processes, typical maturation and fragmentation, appears to vary in different chains, proglottids, and regions. In some chains typical maturation has been observed only rarely, and fragmentation very frequently in the testes, yet these chains apparently produce as many spermatozoa as others; in some proglottids of certain chains the maturation-phenomena are similarly very infrequent while fragmentation is of common occurrence, while in other proglottids typical maturation is more frequent, and finally, in many proglottids the maturation-phenomena have been observed much more frequently in those testes which occupy the lateral regions of the proglottid, while fragmentation appears to be more characteristic of the testes in the middle regions.

The first cleavage of the egg is at least usually, if not always mitotic, but in later stages amitosis becomes the characteristic method of division, mitosis appearing only occasionally, and then in the larger nuclei (Child, '07*d*). Throughout the stages of cleavage observed nuclear division is far in advance of cytoplasmic division.

In the development of somatic structures in the proglottid mitosis is almost never seen, amitosis being the typical method of division. When mitoses occur they occur as isolated cases, usually at or near the periphery of regions of proliferation.

If my observations are correct, amitosis is the more common method of division in the generative cycle, except during the period of maturation and early cleavage. In the somatic cells of the adult body it appears to be the usual method at all times. Later embryonic stages inhabiting the intermediate host are not at present known, but conditions will probably be found to be similar in these.

Considering these facts in the light of the hypothesis presented above, we find them in general in accord. In the first place *Moniezia* produces rapidly an enormous number of generative cells and this involves a very large amount of assimilation. These, according to our hypothesis, are conditions favorable to the occurrence of amitosis, and we have found that amitosis is the characteristic method of division in the development of ovaries and testes.

But even in this period mitoses occasionally occur, their relative frequency differing in different chains, proglottids and regions. These differences may be due to local differences in nutrition; doubtless different chains and often different proglottids, receive different amounts of nutritive material, and in those best nourished, some of the nuclei may attain equilibrium occasionally. The fact that mitoses were more frequently observed near the lateral borders than in the middle of the proglottid may be due to similar differences in condition. Near the lateral border the proliferating regions — chiefly testes — are less numerous than in the middle regions and the absorptive surface is relatively greater hence more nutritive material may be available for each, and conditions permitting mitosis may be more frequently attained than elsewhere.

Moreover, mitoses in the developing testes and ovaries seem to occur more frequently in the later stages during the last division preceding the growth period, than in earlier stages. It is probable that in these stages the stimulus to growth is not as great as in earlier stages and some of the nuclei attain a condition of equilibrium.

It is by no means certain that the peculiar process of fragmentation of the spermatocyte-nuclei (Child, '07*b*) is to be regarded as due to the same conditions as other cases of amitosis. On the other hand, there can be little doubt that the conditions which, according to the hypothesis, favor amitosis are present in the testes. The development of each testis involves the formation of a relatively enormous amount of nuclear and cytoplasmic material and each prologottid contains hundreds of testes. Failure to attain equilibrium might be expected here if anywhere. Indeed the frequent degeneration of masses of cells in the testes (Child, '07*b*) seems to indicate very clearly that insufficiency of nutrition and failure to attain equilibrium exist, especially as this degeneration is much more frequent in some chains and proglottids than in others. Apparently some cells are forced so far from equilibrium that they can no longer exist. It has been noted (Child, '07*b*) that such degeneration of cells was not observed in stages from the beginning of the growth-period to the spermatid. It is not improbable that cells which once enter upon

the growth-period possess sufficient energy to obtain nutritive material, notwithstanding the demands of their rivals in earlier stages, but it is also possible that some of these cells are so far from a condition of equilibrium that they cannot go through the maturation mitoses following the growth-period. Such cells are probably those in which fragmentation occurs. Certainly the process of fragmentation in the spermatocytes (Child, '07*b*) presents no difficulties to such an interpretation. In it most of the nuclear substance disappears and a few small nuclei are formed from what might almost be regarded as the debris of the original nucleus. Apparently the old nucleus is no longer able to exist as a physiological system and small parts of it form new systems. The special form of fragmentation in these cases may be merely the result of special conditions which are not present in the primitive cells of earlier stages.

It is evident then that these cases of fragmentation in the spermatocytes can readily be interpreted in the same manner as the amitoses in other stages. Whether the resulting nuclei actually take part in the formation of spermatozoa is a question which cannot be decided at present.

The typical spermatocytic mitoses were observed more frequently in testes situated in the extreme lateral regions of the proglottids, fragmentation apparently being much more frequent in the middle regions (Child, '07*b*). This fact likewise is probably to be regarded as favoring the suggestions made above. As was pointed out, in the extreme lateral regions of the proglottid the testes are not as numerous as in the middle regions and the resorptive surfaces from which nutritive material may reach them are relatively greater than in the middle regions. It may well be that the cells in these testes attain more frequently than others a condition in which mitosis is possible.

As regards the frequency of amitosis in cleavage of the earliest stages the fact that nuclear division is always far in advance of cytoplasmic division, except in those blastomeres which divide mitotically (Child, '07*d*) seems to indicate the existence of a strong stimulus to nuclear division in the nuclei dividing amitotically. Apparently most of the nuclei are forced by some factor to divide much more rapidly than they acquire correlations with

the surrounding cytoplasm, and so do not attain a condition in which the cyclical processes characteristic of mitosis can occur. It is not possible to determine the nutritive conditions with any certainty at this stage. It is very evident in the later stages, however, that those regions of the egg where the nuclei are smallest and amitosis is most frequent are regions from which the yolk is absent (Child, '07*d*, Figs. 27, 29, 30, 31). In the yolk-bearing regions the nuclei divide much less frequently and more often mitotically than in other regions. These facts point in the same direction as those already cited with respect to other stages.

In the somatic structures of the proglottid, mitosis has never been observed except in the lateral regions of the proglottid and very rarely there. When mitosis has been observed in the development of the genital ducts it was usually at or near the periphery of the proliferating region, in one of the cells which was evidently less intimately involved in the proliferation than those nearer the middle. These facts are in line with the preceding. Moreover the somatic cells usually possess only a very small amount of undifferentiated cytoplasm and this may be a factor in determining the physiological condition of the nuclei and so the form of division.

It would appear then that the facts concerning occurrence and relative frequency of amitosis and mitosis in *Moniezia*, as well as in other forms, do not conflict with the suggestions made by way of interpretation. There can I think be little doubt that the two forms of division correspond to different physiological conditions in the nucleus. Judging from the visible phenomena, it also seems probable that mitosis is associated with cyclical, and amitosis with acyclical processes. The questions as to the availability of nutritive material and "equilibrium" are more obscure and complex, for they concern not merely the presence or absence of nutritive material outside of the cell, but, and probably chiefly, its availability within the cell and for the nucleus. Various factors, such as quantity and quality of cytoplasm, size, form, and condition of nucleus, etc., may conceivably play a part in determining the physiological conditions in the cell. Moreover, we know little regarding the nature of nuclear equilibrium. I have used the term merely with reference to a condition in which cyclical processes with periodical reversals occur.

Doubtless, also, there are characteristic differences in different species. In the life-history of *Moniezia*, for example, rapid and enormous growth is a characteristic feature. In such a form the stimulus to division and growth must be more powerful or else the nuclei must react more readily than in other species in which the life-history does not involve such extensive growth. Whichever the case, we may expect to find the acyclical nuclear phenomena more characteristic of the species with extensive or indefinite growth than of others, simply because in the former the amount of synthesis is much greater and relatively more rapid than in the latter. If amitosis is associated with these extreme assimilative conditions, as our hypothesis postulates, then its distribution and frequency will follow the same rule.

Similar differences may be expected in different organs and regions of the individual, and so far as our knowledge goes at present, they appear to exist. Amitosis seems to be more characteristic of rapidly growing or assimilating organs and regions than of other regions.

If these observations and suggestions are correct, we can no longer regard mitotic figures as the sole criterion of nuclear division in organisms. In many forms, such, for example, as *Planaria*, in mid-summer, when growth and nuclear division are very rapid and fission is occurring every few days, mitoses are rarely seen, but amitoses are very abundant. In various cases of form-regulation, which were formerly supposed to occur without cell-division because no mitoses were observed, amitosis is very frequent.

Furthermore, if amitosis may occur in the normal developmental cycle and if it is especially characteristic of regions of rapid growth, as the facts indicate, we cannot depend upon the distribution of mitotic figures in developing tissues as an indication of the rapidity of cell-division and growth in different regions. The regions where mitoses are most abundant may be the regions of slowest division instead of the only regions where division is occurring.

The bearing of these and other observations on certain cytological hypotheses is briefly discussed in another paper (Child, '07*c*) and requires no further consideration here. I hope in

future to continue these observations on other species and to offer further evidence for or against the hypothesis presented here, together with a more extended discussion of the observations of others.

April, 1907.

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Explanation of Plate VIII.

Fig. 1. A very early stage of the developing genital ducts in the region lateral to the longitudinal nephridial canals. The width of the figure from right to left represents approximately the width of the region involved in proliferation and the axis of the duct corresponds with a line through the middle of the figure from top to bottom

Fig. 2. A somewhat later stage in the development of the genital ducts, from the same region and showing one case of mitosis. Plane of section as in Fig. 1.

Fig. 3. The developing vas deferens near its inner end. The width of the figure represents the width of the proliferating region. Plane of section as in Fig. 1.

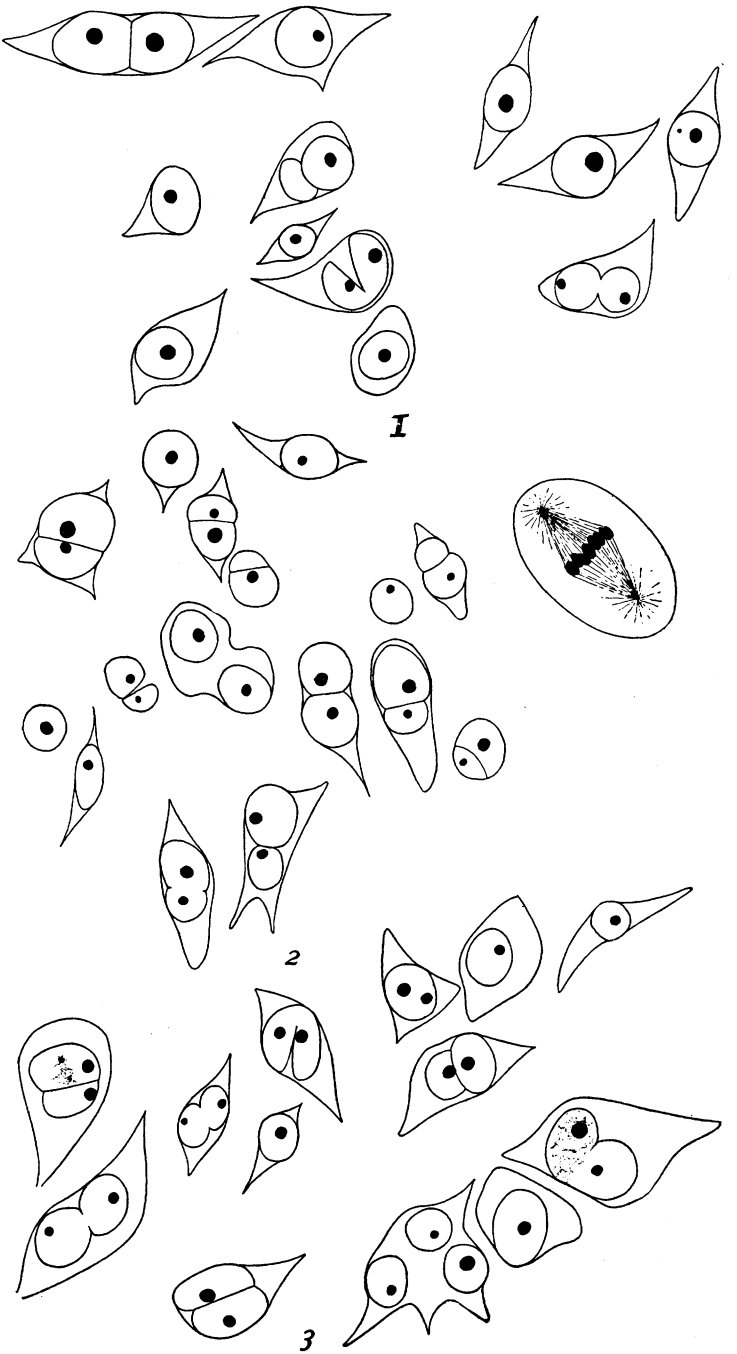
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PLATE IX.

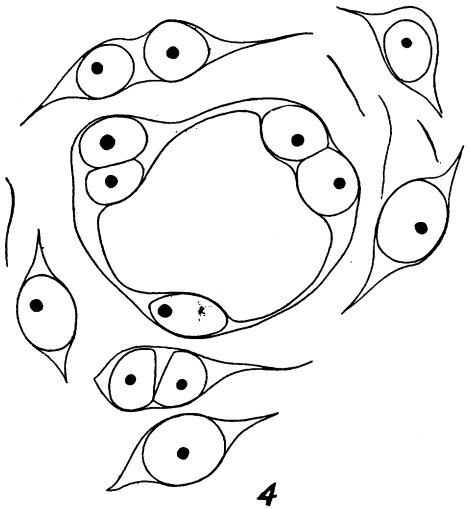
FIG. 4. Cross-section of the vas deferens at a somewhat later stage.

FIG. 5. Longitudinal section of a vas efferens.

FIG. 6. A portion of the wall of the developing oviduct, showing one case of mitosis.

FIG. 7. Probably a developing nephridial duct in cross-section.

FIG. 8. From the region of the lateral longitudinal nerve-cords in the "neck."



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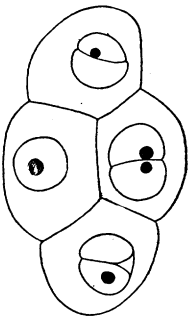

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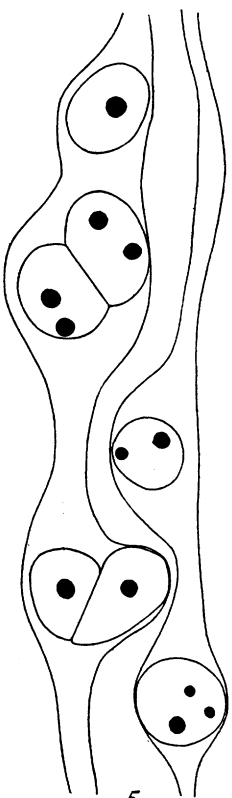

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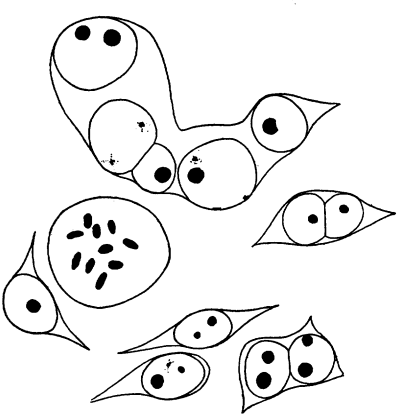

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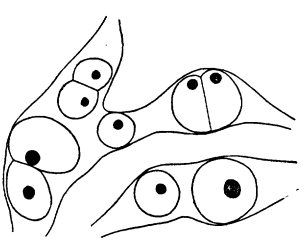

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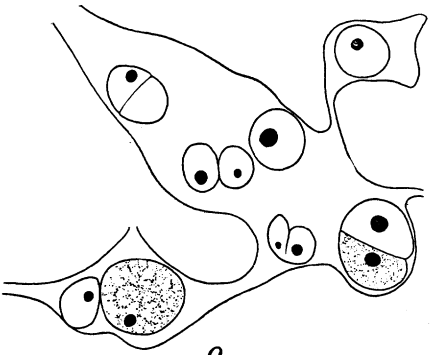
PLATE X.

FIG. 9. From the region of the lateral longitudinal nerve-cords in the "neck."
FIGS. 10–14. From the general parenchyma in neck-region.
FIGS. 15–16. Interproglottidal glands after differentiation has begun.
FIGS. 17, 18, 19. Cells of the subcuticular layer from the neck-region.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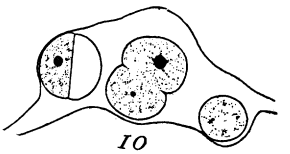
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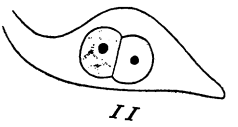
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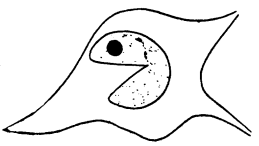
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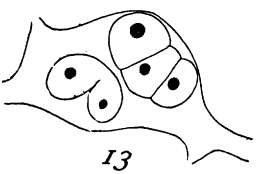
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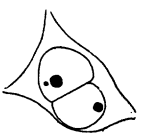
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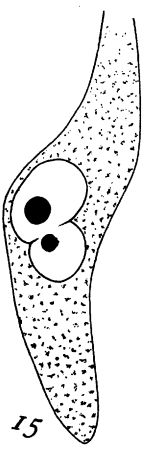
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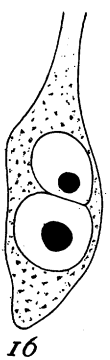
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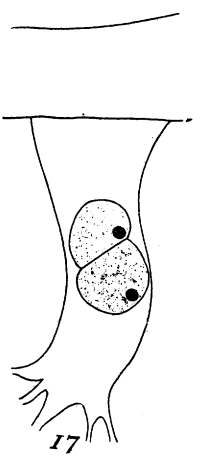
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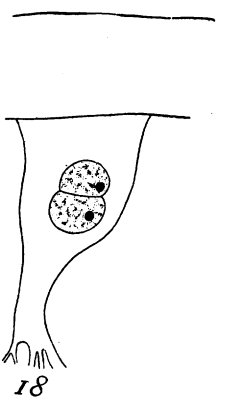
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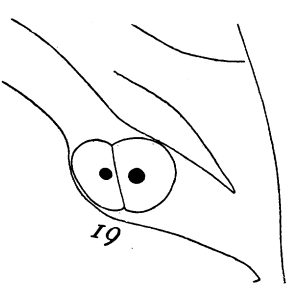
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